SIMILARITY (IDENTITY) OF THE COMPOSITION OF THE EARTHS LOWER MANTLE AND THE BULK COMPOSITION OF THE MOON? P. Jakes[1] and A. Jambon[2], [1] Institute of Geochemistry, Faculty of Sciences, Charles University, Albertov 6, 128 43 Praha 2, Czech Republic (jakes@prfdec.natur.cuni.cz), [2] Department of Petrology, University of Pierre et Marie Curies Paris VI, 4 place Jussieu, 75 005 Paris, France (alj@ccr.jussieu.fr)

The similarity of oxygen isotope ratios in the Earth and the Moon (and differences of the same ratios among the meteorites and the Earth-Moon system) have lead to the suggestion that the Moon has been formed in the same radial distance from the Sun, i.e., in the same solar nebula eddy. The geochemical features of the Moon, i.e., the volatile element depletion, excess of refractories, depletion of iron and siderophile elements and highly reduced state of the iron as compared to chondrites are in contrast to the geochemical features of the recent upper mantle of the Earth. The abundance of refractory oxyphile elements in the Earth compared to that of the Moon are lower, whereas the abundance of siderophile elements and volatile elements are higher in the upper mantle of the Earth than in the Moon.

Advances in the understanding of impact phneomena in the seventies and eighties have lead to the hypothesis that the formation of the Moon was due to the collision of a Mars-sized body with the early Earth. The Moon was formed from the impactor´s mass and from the Earth´s mantle. In order to explain the differences in the compositions of both bodies, e.g., higher contents of refractory elements or lower contents of siderophile element in the Moon as compared to the Earth explanation was sought in a high proportion of projectile material, which was strongly fractionated.

Although the estimates of the bulk Moon composition made by different authors differ, the basic compositional feature is the ability of the bulk Moon composition to provide a melt, that (after some fractional crystallization) crystallizes large amounts of plagioclase. It is the requirement of a high content of the refractory elements, such as Ca and Al. If, however, the impactor is responsible for the high contents of refractory and low contents of siderophile elements, it must have been strongly fractionated body with respect of refractories and still maintain the same oxygen isotope ratios as the Earth. Hence, it must have been formed in the same part of solar nebula where the Earth was formed. The formation of the Moon then requires the existence of two compositionally different, isotopically identical, bodies that were formed in the same part of the nebula.

Ringwood, Wanke & Dreibus and others have shown that the Moon has been formed after the formation of the Earth´s core and it was noted e.g., by Drake that the Moon is more depleted in siderophile elements compared to the upper mantle of the Earth. The additional siderophile element separation must have taken place after the separation of the lunar matter from the protoEarth if the Moon has been formed from a material similar to the upper mantle of the Earth. In order to explain these differences an another event, such as the formation of the lunar core, a natural consequence of large scale melting of the Moon, was advocated.

Wood offered another explanation. He pointed out that the present day estimates of the terrestrial mantle composition may not be representative of the composition of mantle at the time of the hypothetical fission event. Such contention would require that the lower and upper mantle are chemically different, the idea that appeals to many petrologists, providing an explanation to the observation, that the Earth´s upper mantle was not in equilibrium with a metallic core. Such scenario would also appeal to those who advocate a two cell mantle. A late cometary veneer, that has accreted to the Earth after the Moon forming material has been removed, would explain the abundances of siderophile and volatile elements in the upper mantle of the Earth and could account for the abundances of refractory elements in the Moon and, consequently, in the lower mantle of the Earth.

We have argued elsewhere (Jakes et al.,) that temperatures substantially higher than the liquidus temperatures of silicate melts could be achieved if the planetary magma ocean is large and the system is not buffered by the presence of solid phases. Superheat may provide some means of changing the chemical composition (by volatilization) and through the heat induced reduction formation of metallic species of siderophile and transitional elements (decomposition of oxide phases). The impact event provides the mechanism of the emplacement of the refractory material into the terrestrial orbit and probably the removal of the high temperature atmosphere.

The possibility that the Moon has been formed in the early history of the Earth, that had (at that stage) a different composition than the recent upper mantle, offers an alternative explanantion . All the characteristic features (i.e., volatilization, refractory composition, and reduced nature) are mutually related through a high temperature of the forming protoEarth that has been followed by the impact induced fission of lunar material. This early composition is possibly preserved in the lower mantle of the Earth which retained its refractory chemical identity since this stage.

References: Drake M. J.,(1986) Ringwood A.E.,(1986) Wanke H., & Dreibus (1986) Wood J.A. (1986) in W.K. Hartmann, R.J., Phillips and G.J. Taylor (editors) Origin of the Moon, LPI, 1986. Jakes P., Reid A.M., and Casanova I., 1992, LPSC XXIII, 597 - 598.